RESEARCH MEMORANDUM

THE PROPERTIES OF THREE CAST POLYESTER RESINS OF SIERRACIN 212, 212A, AND 250A

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National Bureau of Standards

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SUMMARY

Physical properties of samples of three cast polyester resins known as Sierracin resins were investigated. Tests were made to determine specific gravity, index of refraction, Rockwell hardness, Tukon indentation hardness, effect of exposure to accelerated and outdoor weathering, Munsell color, resistance to accelerated service tests, crazing resistance under stress, flexural strength, Izod impact strength, and Taber abrasion resistance. Tables of the values obtained for these physical properties are included in the report.

INTRODUCTION

The problem of obtaining suitable materials for use as glazing for pressurized aircraft has been of considerable interest to the aircraft industry. Failures of such materials have occurred in the past caused in large part by loss in strength due to crazing of the material. Such failures can be held to a minimum only by constant inspection and replacement of doubtful parts. Materials of the type reported on herein are being used as pressurized aircraft glazing and have exhibited improved crazing resistance. This investigation was conducted by the National Bureau of Standards to provide some physical data concerning these materials so that such information might be available to potential users in the aircraft industry.

The publication of these data does not constitute an endorsement by the NACA of the products referred to in the report.

TEST MATERIALS, METHODS, AND RESULTS

Three samples of Sierracin, a new transparent plastic, were received from the Sierra Products Company, Compton, California, in March 1950. Tests were made to determine specific gravity, index of

refraction, Rockwell hardness, Tukon indentation hardness, effect of exposure to accelerated and outdoor weathering, Munsell color, resistance to accelerated service tests, crazing resistance under stress, flexural strength, Izod impact strength, and Taber abrasion resistance in accordance with Federal Specification L-P-406a and Amendment 1, dated April 15, 1949, where applicable. All tests were made at 23° C (73.5° F) and 50-percent relative humidity after storing at these conditions for at least 96 hours prior to test.

The samples are identified as follows:

Sample designation	Thickness (in.)	Specific gravity	Index of refraction, n_D	Rockwell indentation hardness
212	0.260	1.23	1.551	M105
212A	.249	1.21	1.559	M90
250A	.264	1.22	1.539	M107
Lucite 201	.060	1.18	1.495	M87

The specific gravity, index of refraction, and Rockwell indentation hardness were measured in accordance with Methods 5011, 3011, and 1081, respectively.

Tukon Indentation Hardness

The Tukon indentation hardness was measured in accordance with the method described in reference 1. The indentation was made with a 100-gram load. Three tests were made on each sample. The results are as follows:

Sample designation	Tukon indentation hardness (Knoop number)
212	15.6
212A	15.5
250A	15.9
Lucite 201	15.7
Plexiglas I-A	17.7
Plexiglas II	20.0

Resistance to Accelerated and Outdoor Weathering

Three specimens of each sample of Sierracin and five specimens of methyl methacrylate were exposed to a 240-hour sunlamp-fog cyclic accelerated weathering test in accordance with Method No. 6021. Light transmission and haze were measured initially and after exposure. Methyl methacrylate gave light transmission of greater than 90 percent and haze of less than 1.0 percent, initially and after 240 hours of accelerated weathering. There was no change in color or appearance of the methyl methacrylate. The results for Sierracin are given below.

Two specimens of each sample of Sierracin were exposed from June 6, 1950, to August 17, 1950, to outdoor weathering on the roof of the Industrial Building of the National Bureau of Standards at an angle of 45° to the horizontal, facing south. Light transmission and haze were measured initially and after the 10-week exposure period.

The results are as follows:

Sample designation	Light transmission (percent)	Haze (percent)
Initial[1]		
212	88.2	1.8
212A	88.0	3.3
250A	89.2	1.9
After 240 hours of accelerated weathering		
212	88.5	2.8
212A	87.6	3.6
250A	88.9	2.0
After 10 weeks of outdoor weathering		
212	86.0	2.0
212A	86.4	2.1
250A	86.2	2.7

[1]The initial light transmission and haze values are averages of measurements made on five specimens. Three specimens were exposed to accelerated weathering and two to the outdoor weathering test.

Munsell Color Determination

The colors of the samples were determined initially and after the outdoor weathering in accordance with the Munsell color system described in reference 2. Matching of the sample with the color chart was done in a room with north light. A white background was used. The Munsell colors and the ISCC-NBS designations are given in the following table:

Sample designation	Munsell color	ISCC-NBS color designation
Initial		
212	2.5GY 9/1	Yellowish white
212A	2.5GY 9/0	White[1]
250A	7.5Y 9/2	Yellowish white
After 240 hours of accelerated weathering		
212	7.5Y 8/3	Weak yellow
212A	7.5Y 8/3	Weak yellow
250A	7.5Y 8/4	Weak greenish yellow
After 10 weeks of outdoor weathering		
212	7.5Y 8/4	Weak greenish yellow
212A	7.5Y 8/4	Weak greenish yellow
250A	7.5Y 8/6	Moderate greenish yellow

[1]A white background was used for all these measurements.

Accelerated Service Test

Three specimens of each sample and three each of Lucite 201 and Plexiglas I-A were subjected to an accelerated service test according to procedure III in Method No. 6011.

Initial measurements of length, width, thickness, and weight were made. The specimens were then placed in a desiccator over a saturated solution of sodium chloride to provide an atmosphere of 70- to 75-percent relative humidity and the desiccator was put in the oven at a temperature of 160° F (71° C). After 24 hours the specimens were removed from the desiccator and replaced in the oven at the same temperature with a relative humidity of less than 10 percent for 24 hours. This process constituted a cycle, which was repeated five times.

Measurements were made in the same manner as initially after the first, second, and fifth cycles.

The changes in weight and dimensions are as follows:

Sample designation	Cycle	Decreases in dimensions			Change in weight (percent)
		Length (in.)	Width (in.)	Thickness (in.)	
212	1	0.0006	0.0002	0.0005	-0.16
	2	.0017	.0008	.0006	-.12
	5	.0025	.0010	.0007	-.17
212A	1	.0231	.0111	.0060	-.06
	2	.0245	.0113	.0061	-.03
	5	.0251	.0114	.0064	-.17
250A	1	.0005	.0001	.0003	-.12
	2	.0012	.0003	.0004	-.03
	5	.0014	.0004	.0004	.06
Lucite 201	1	.0017	.0009	.0010	-.17
	2	.0031	.0011	.0012	-.12
	5	.0071	.0018	.0016	-.06
Plexiglas I-A	1	.0008	.0007	.0009	-.020
	2	.0030	.0010	.0014	-.020
	5	.0099	.0022	.0024	-.025

The specimens were 3.0 inches long, 1.00 inch wide, and nominally 0.25 inch thick. All the above values of dimensional change are based on the initial values.

Crazing Resistance under Stress

Tests for crazing resistance under stress were made in accordance with Method No. 3053. Benzene, methyl ethyl ketone, and a 3-percent solution of trisodium phosphate were applied to two specimens of each sample of Sierracin under a stress of 1000 pounds per square inch. No crazing occurred.

Benzene was also applied to the three samples of Sierracin under a stress of 5000 pounds per square inch. No crazing occurred.

No crazing of Lucite 201 occurred under a stress of 1000 pounds per square inch with benzene, but Lucite 201 crazed from contact with methyl ethyl ketone at 1000 pounds per square inch, and from contact with benzene at 1400 pounds per square inch.

Flexural Tests

The flexural tests were made in accordance with Method No. 1031. The tests were made on a Baldwin-Southwark universal hydraulic testing machine, using the 240-pound range to measure the load. The tests were made at a span-depth ratio of 16:1. The rate of cross-head motion was 0.05 inch per minute. The average flexural strength, average modulus of elasticity, and ranges of these values for the four specimens of each sample tested are as follows:

Sample designation	Flexural strength		Modulus of elasticity (1)	
	Average	Range	Average	Range
	(lb/sq in.)	(lb/sq in.)	(lb/sq in.)	(lb/sq in.)
212	17,500	16,900-17,800	374,000	367,000-379,000
212A	12,900	12,700-13,200	270,000	250,000-283,000
250A	15,500	12,100-17,000	387,000	383,000-391,000

[1]The modulus of elasticity is a secant modulus for the stress range 0 to 5000 pounds per square inch.

The deflections at maximum load were approximately 0.5, 0.7, and 0.4 inch for samples 212, 212A, and 250A, respectively.

Methyl methacrylate has a modulus of elasticity in the range 350,000 to 450,000 pounds per square inch and flexural strengths in the range 12,000 to 14,000 pounds per square inch.

Izod Impact Test

Izod impact tests were made in accordance with Method No. 1071. An impact machine with a capacity of 2 foot-pounds was used. The results are as follows:

Sample designation	Number of specimens	Izod impact strength	
		Average	Range
		(ft-lb/in. of notch)	(ft-lb/in. of notch)
212	10	0.34	0.25-0.41
212A	11	.41	.37-0.44
250A	10	.33	.30-0.41
Plexiglas I-A	28	.43	.36-0.48

Taber Abrasion

The abrasion tests were made on two specimens each of Sierracin 212 and Lucite 201 in accordance with Method No. 1092.1. CS-10 wheels with a 1000-g load on each wheel were used. The Sierracin was abraded for 150 revolutions and the Lucite for 100 revolutions. The average light transmission and haze after each cycle and the number of revolutions for each cycle are as follows:

Sample designation	Total number of revolutions/cycle	Light transmission	Haze
Sierracin 212	10	86.9	4.8
	25	86.6	11.4
	50	85.2	22.8
	75	84.4	33.8
	100	83.6	36.7
	125	82.8	43.9
	150	82.6	46.0
Lucite 201	10	90.9	12.2
	25	91.0	15.8
	50	89.6	23.4
	75	90.0	25.6
	100	89.3	27.8

These results are shown graphically in figure 1.

SUMMARY OF RESULTS

Sample 212A is the softest of the three samples of Sierracin. This sample had the greatest dimensional changes in accelerated service test at 70- to 75-percent relative humidity and 160° F and the lowest flexural strength and modulus of elasticity.

The other two samples had only small dimensional changes in the accelerated service test, had about the same flexural stiffness and flexural strength as methyl methacrylate plastic, and did not undergo stress-solvent crazing in contact with methyl ethyl ketone and benzene under conditions which cause crazing of methyl methacrylate plastic. All three Sierracin samples had good resistance to accelerated weathering.

National Bureau of Standards
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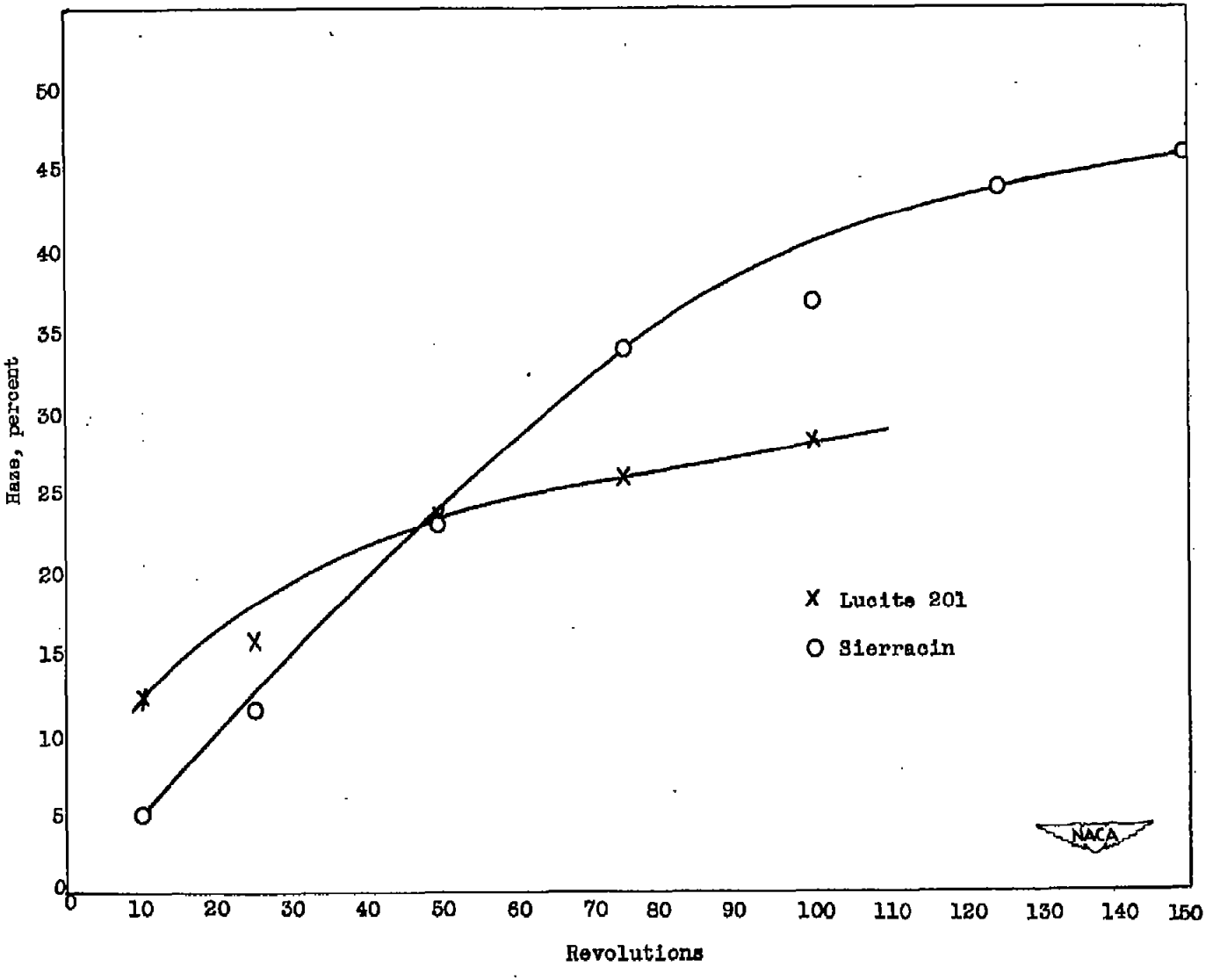

Figure 1.- Taber abrasion of Lucite 201 and Sierracin 212.